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CONDENSER HEAT REJECTION SYSTEMS

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## 1. SUMMARY

During the past reporting period the investigation of large diameter jet condensers was continued. Testing of the first geometry (see EOS Report 1538-ML-13) was concluded, and initial tests of a similar geometry without the constant area throat were performed. Stable performance, together with high pressure rise ratios (1.0-2.9) were obtained over a wide range of variables with the former test section (see below).

Pressure rise results have deviated somewhat from the results of the analysis which was based on the assumption of constant pressure in the mixing chamber. The deviations can be qualitatively explained by variations in the mixing section pressure profile. An analysis, therefore, has been initiated to include the case of varying pressure in this region.

Fabrication of the multitube jet condenser test unit was continued. The assembly is now 90 percent complete. A series of tests with air are being planned to determine the flow distribution resulting from the vapor plenum chamber design. Upon completion of these tests and correction of any maldistribution, the test unit will be installed in the 10 kw test rig.

Two additional failures of boiler heating elements occurred during the past reporting period. These failures were felt to be mainly due to aging of the heaters and damage to other electrical components received during a previous heater failure. (See EOS Report 1588-M-14). Consequently, all boiler heaters were replaced, all electrical circuits were tested and repaired, and improved circuit protection installed. All electrical components are performing satisfactorily since these modifications were made.

## 2. TECHNICAL DISCUSSION

The range of variables (independent and dependent) tested for the initial large diameter jet condenser (see Table I of EOS Report 1588-M-13) is shown in Table I. In order to determine the operating characteristics of the jet condenser, rather wide ranges were tested; for example, vapor pressure and density ratio were varied by a factor of ten. Liquid injection flow rate and mass flow ratio were varied by a factor of four. In addition to the wide variable ranges tested, several significant extremes which were investigated should be noted. For example, the jet condenser exhibited stable performance characteristics and net pressure rise with extremely low values of vapor velocity (25-40 fps) and liquid velocity (2.5-3 fps). Differences between outlet temperature and vapor temperature as low as 7 °F were obtained. For this value the spray utilization factor attained a value of 0.95 (the maximum possible is unity). Stable condensation was achieved for very low vapor pressures (4.0 psia) and vapor densities (0.064 lb/ft<sup>3</sup>) with a net pressure rise through the condenser. Vapor-liquid pressure rises of as high as 20.5 psid were obtained with pressure rise ratios as high as 2.9. In summary, the large diameter jet condenser has proved very flexible in operation. Use of a larger geometry (0.75" ID) appears to have reduced the relative magnitude of the losses which were obtained when testing smaller diameter (.019" ID) test units, and performance has improved in nearly every respect. The test data summarized in Table I are presently being analyzed and correlated.

It should be emphasized that the variable ranges of Table I are not completely independent. For example, higher values of vapor velocity were obtained for the lower values of vapor pressure and vapor density. High values of spray utilization factor were obtained

for the higher values of vapor density and lower values of liquid velocity. Moreover, data reduction has been verified thus far only by spot checks. Further verification is required before these values can be considered final.

As discussed above, fabrication of the multitube jet condenser test unit is nearing completion. Figures 1, 2, and 3 are photographs of the present assembly and component parts. In Fig. 1, a general view of the assembly is provided. (The unit will be installed in the 10 kw test rig with liquid inlet plenum and valves below the jet condensers.) Vapor enters a plenum chamber from the right through a baffle. The plenum is designed such that the vapor velocity is less than 1 fps. Vapor flows from the plenum into each of three jet condenser test units. Subcooled liquid flows into a plenum from the left into each of three delivery lines, and through valves to the injectors. (The discharge coefficients of the valves were measured and the maximum difference between valves is 1 percent). A remote control is provided on the middle valve so that it can be adjusted from wide open to some intermediate value to perturb the injected liquid distribution.

Figure 2 presents a view of the liquid injectors and vapor inlet orifices. Proper alignment of the injectors was ensured by use of a jig fixture during welding. The resultant liquid flow exists from each of the jet condensers to the left (Fig. 1). All three flows are then collected in a plenum (Fig. 3) and returned to the pump. The use of low velocity plenum chambers is expected to reduce problems which might arise from having flow maldistributions external to the test units. Completion of the assembly and installation in the test rig is planned for the next reporting period.

### 3. LABOR HOURS

During the period 31 December 1961 to 27 January 1962 a total of 773 labor hours were expended.

#### 4. FUTURE EFFORT

During the next reporting period the following progress is planned:

- a. Continued testing of large diameter jet condensers
- b. Completion and installation of multitube test unit
- c. Analysis

Figure 4 furnishes a comparison of technical effort estimated at the inception of the four month extension with that actually expended.

TABLE I RANGE OF VARIABLE

(For Large Diameter Jet Condenser (No. 5)\*)

INDEPENDENT VARIABLES

1. Vapor Temperature	550-790 °F
2. Vapor Pressure	4.0-41.0 psia
3. Density Ratio (Liquid/Vapor)	1250-11,800
4. Vapor Flow Rate	120-230 lb/hr
5. <del>Vapor Velocity</del>	26-240 fps
6. Injected Liquid Flow Rate	1730-7000 lb/hr
7. Injected Liquid Velocity	2.5-10.5 fps
8. Mass Flow Ratio (Liquid/Vapor)	12.7-42.8
9. Liquid Temperature Rise (Radiator $\Delta T$ )	94-310 °F
10. Outlet Subcooling	7-100+ °F
11. Spray Utilization Factor	0.48-0.95

DEPENDENT VARIABLES

1. Pressure Rise	1.0-20.5 psid
2. Pressure Rise/Liquid Kinetic Energy	0.9-2.9
3. Pressure Rise/Vapor Kinetic Energy	12.5-130
4. Condensation Length	~ 1.0"

\*All values represent the extremes tested for "stable operation" of the jet condenser; i.e., all liquid at outlet and interface in constant area throat.

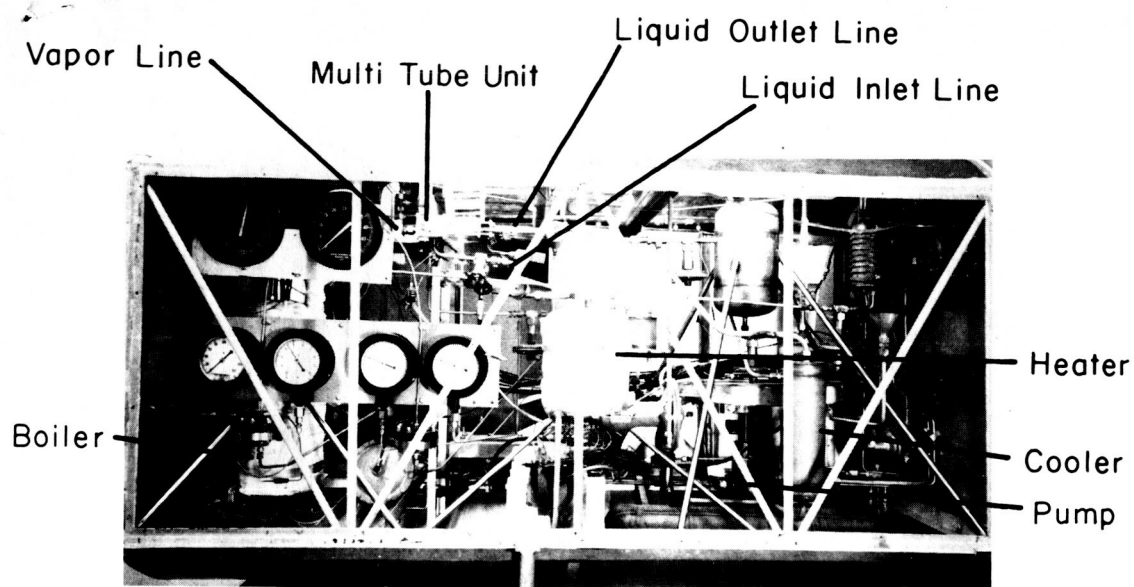


FIG. 1 10 KW TEST LOOP WITH MULTITUBE UNIT INSTALLED

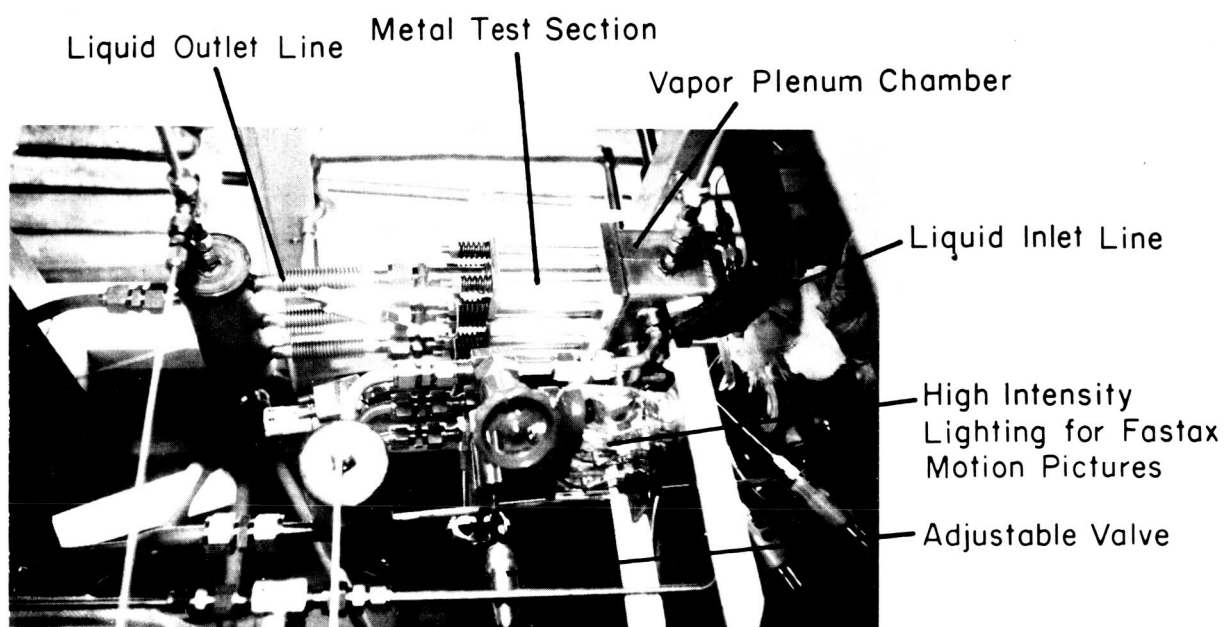


FIG. 2 MULTITUBE TEST UNIT INSTALLED IN 10 KW TEST LOOP

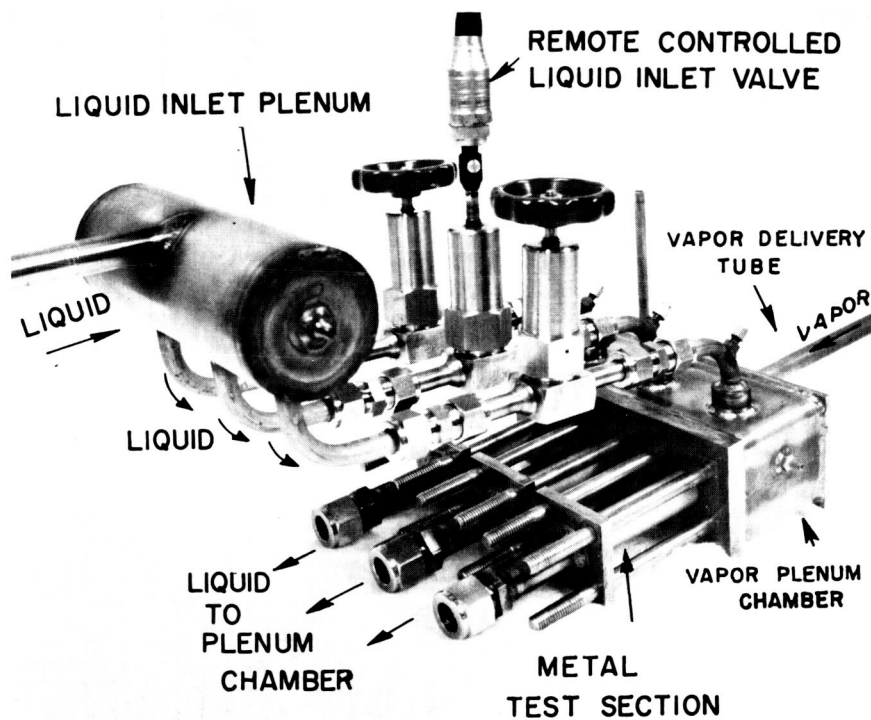


FIG. 1 MULTI-TUBE JET CONDENSER ASSEMBLY

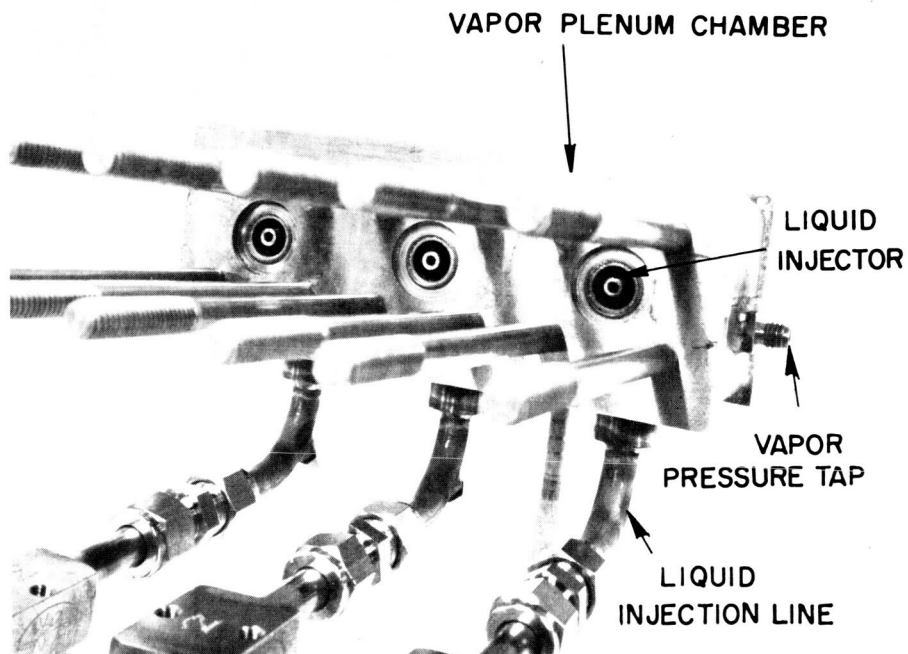


FIG. 2 MULTI-TUBE JET CONDENSER - LIQUID INJECTORS AND VAPOR INLET STRUCTURE



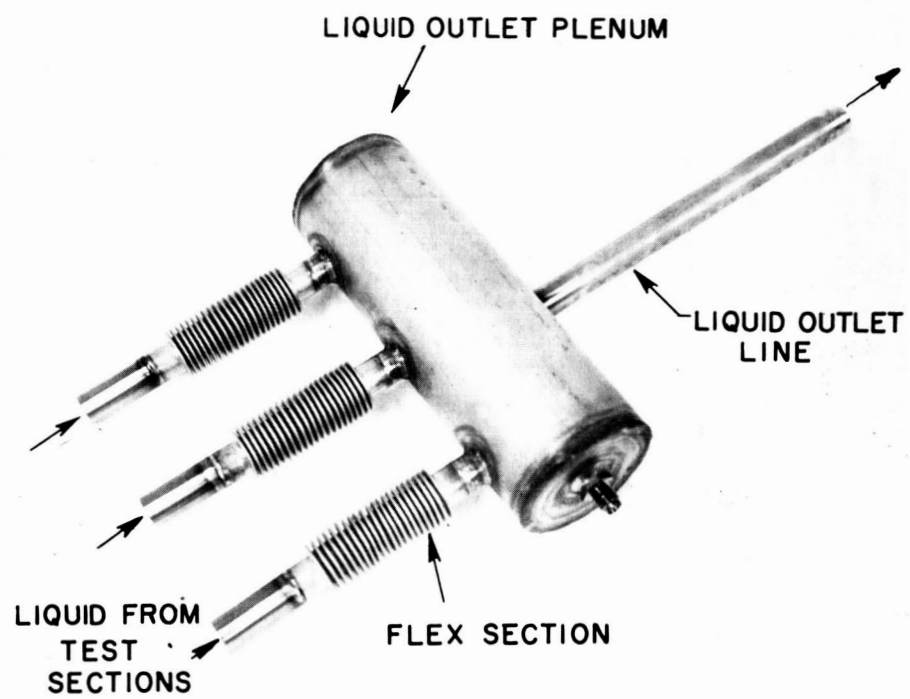


FIG. 3 MULTI-TUBE JET CONDENSER - LIQUID OUTLET PLENUM CHAMBER

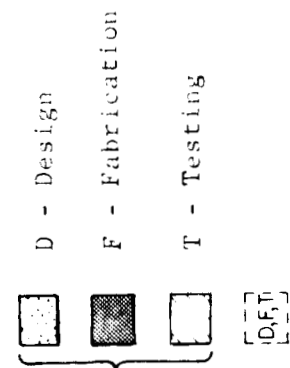
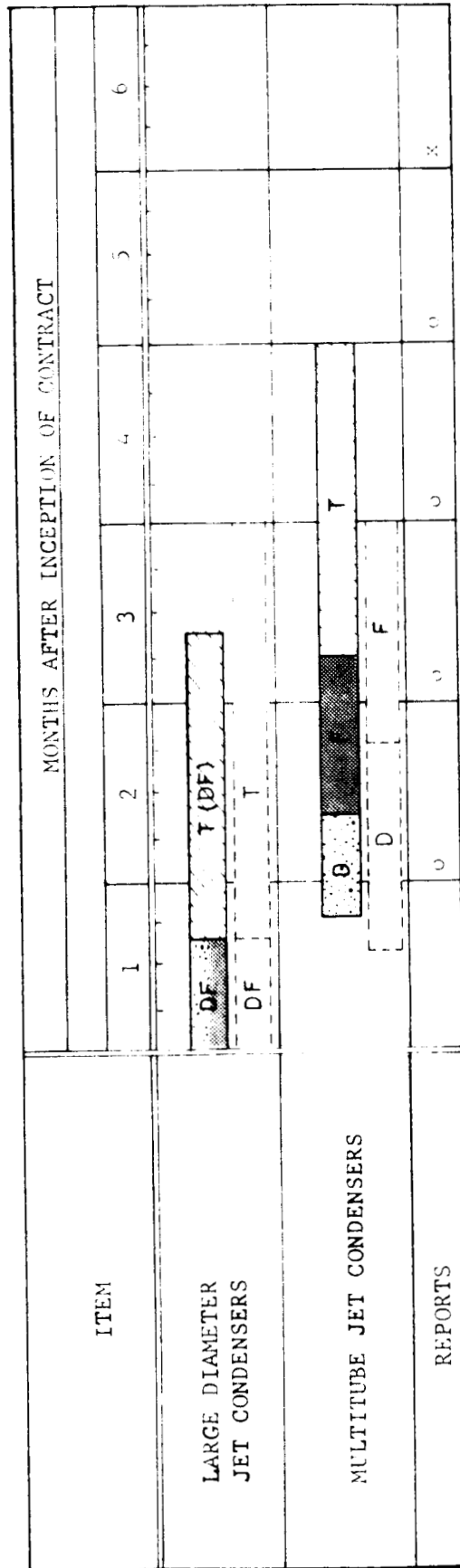


FIG. 4 ESTIMATED TIME SCHEDULE

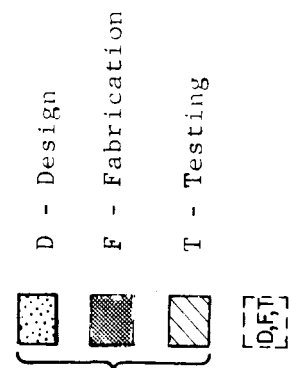
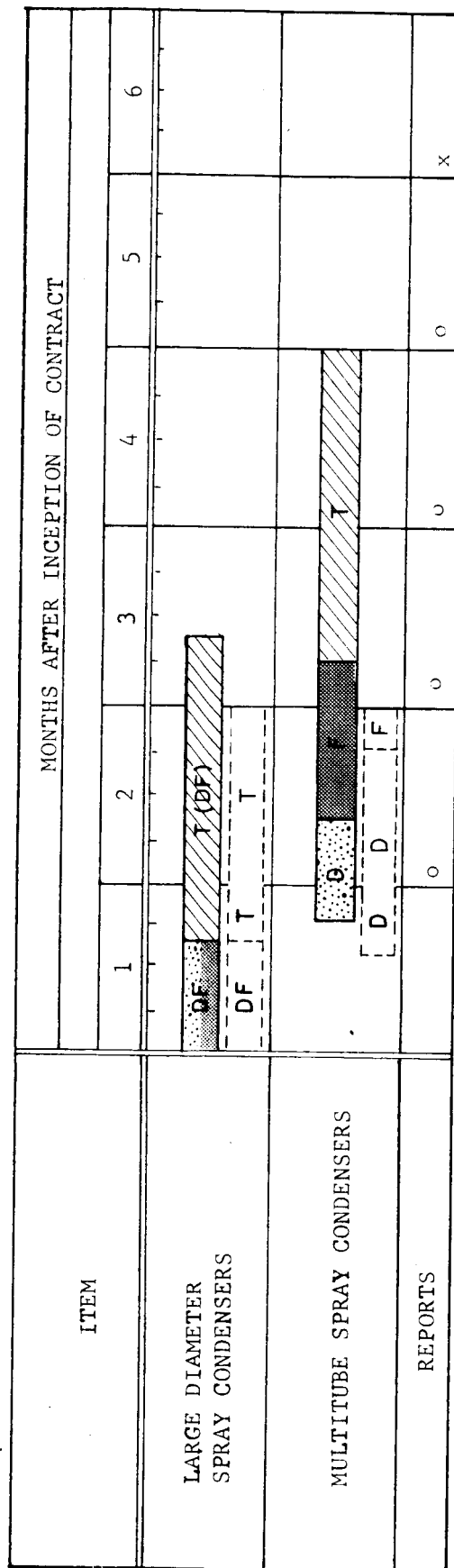


FIG. 1 ESTIMATED TIME SCHEDULE